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original article

The influence of subjective intensity control on perceived fatigue and capillary lactate in two types of resistance training

A influência do controle subjetivo de intensidade sobre fadiga percebida e lactato capilar em duas formas de treinamento resistido

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Abstract – Rating of perceived exertion (RPE) is a method used to control intensity in resistance training (RT). However, few studies have compared acute physiological and perceptual responses between different types of RT. The objective of this study was to compare the acute responses of lactate and perceived fatigue (PF) between manual resistance training (MRT) and free weight RT (FWRT) with intensity control by RPE, and to evaluate the correlation between lactate and PF in both interventions. Fourteen previously untrained men (40.29 ± 8.63 years, BMI = 26.53 ± 5.24 kg/m²) underwent single sessions of MRT and FWRT with intensity control by RPE (5-7 OMNI-RES). Lactate and PF were analyzed pre and post-test. Repeated measures ANOVA and the post hoc Bonferroni test were used for data analysis, adopting a significance level of 5% ($P \leq 0.05$). The effect size was calculated to determine the magnitude of the response and Pearson's correlation coefficient was used to assess the association between lactate and PF. Both interventions increased post-test lactate compared to pre-test levels. However, the increase was greater for MRT. Post-test PF was increased when compared to pre-test levels in both protocols, with no difference between interventions. However, a greater effect size was observed for MRT. The correlation between PF and lactate was moderate in three of the four assessments. In conclusion, the same intensity zone in RPE may elicit different physiological responses in the two types of RT. Thus, the use of RPE for intensity control under these conditions should be viewed with caution.

Key words: Muscle stretching exercise; Physical education and training; Physical exertion.

Resumo – *A percepção subjetiva de esforço (PSE) é um método utilizado para controlar a intensidade no treinamento resistido (TR). Porém há escassez de estudos que comparam respostas fisiológicas e perceptivas agudas entre formas distintas de TR. O estudo teve como objetivo comparar as respostas agudas de lactato (LAC) e fadiga percebida (FAD) entre treinamento resistido manual (TRM) e TR com pesos livres (TRPL) com intensidades controladas por PSE, bem como observar a correlação entre LAC e FAD nas duas intervenções. Participaram 14 homens (40,29±8,63 anos, IMC = 26,53±5,24 Kg/m²) previamente não treinados que foram submetidos a sessões únicas de TRM e TRPL, com intensidade controlada por PSE (entre 5 e 7). LAC e FAD foram analisados nos momentos pré-teste e pós-teste. Para análise dos dados, utilizou-se análise de variância com medidas repetidas e post-hoc de Bonferroni. Adotou-se nível de significância de 5% (P ≤ 0,05). O tamanho do efeito (ES) foi calculado para analisar a magnitude das respostas e o coeficiente de correlação linear de Pearson para verificar associação entre LAC e FAD. Ambas as intervenções aumentaram LAC no período pós-teste em relação ao pré-teste, porém o aumento foi maior no TRM. A FAD aumentou no período pós-teste em relação ao pré-teste, em ambos os protocolos, sem diferença entre eles. No entanto, o ES foi maior para o TRM. A correlação entre FAD e LAC foi moderada em três das quatro avaliações. Foi possível concluir que na mesma zona de intensidade na PSE pode representar respostas fisiológicas diferentes entre duas formas distintas de TR, portanto, a utilização da PSE para controle de intensidade, nessas condições, deve ser vista com cautela.*

Palavras-chave: *Educação física e treinamento; Exercícios de alongamento muscular; Treinamento de resistência*

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INTRODUCTION

The inclusion of physical exercise in health promotion programs is well established in the literature[1,2]. Among the different types and modalities of physical exercise, the participation of resistance training (RT) has increased over time because of its growing popularity and increasing scientific knowledge[1,3].

Popularly, the most common place for the application of RT are weightlifting rooms, environments where the majority of people is concentrated in gyms[4]. In this environment, most exercises are performed using the resistance of free weights and fitness equipment. However, considering that only a small portion of the world population attend gyms[5], recent studies have suggested alternative forms that do not depend on equipment in order to permit the application of RT in nonspecific environments and places such as residential condominiums, hospitals, clinics, basic health units, universities, schools, and companies, among others[6-9].

One alternative of RT that is being investigated is manual resistance training (MRT)[7-10], a concept that uses manual resistance imposed by a second person in the direction opposite to the movement performed by the exercising subject (Figure 1A, 1B). Previous studies have shown that MRT is effective in increasing strength levels in different populations[7-10]. Furthermore, the effects of MRT are similar to those of free weight resistance training (FWRT) as long as the volume and intensity are comparable[7,11]. However, since, in contrast to FWRT, this type of training does not use equipment, the objective control of intensity is not possible and the use of subjective methods, such as rating of perceived exertion (RPE), is therefore recommended for the control of internal load[9,11].

To our knowledge, there are no studies comparing the effects of the use of RPE as a method to control intensity on objective and subjective markers of exercise intensity between MRT and FWRT. Therefore, the objective of the present study was to compare the acute responses of lactate and perceived fatigue (PF) between MRT and FWRT with intensity control by RPE, and to evaluate the correlation between lactate and PF in the two interventions.

METHODOLOGICAL PROCEDURES

Subjects

Fourteen previously untrained healthy men [40.29 ± 8.63 years; body mass index (BMI): 26.53 ± 5.24 kg/m^2], with medical clearance for physical activity, participated in the study. Criteria for exclusion were the use of medications and ergogenic substances, presence of chronic diseases, engagement in physical exercise programs, and medical prohibition to practice exercise. These criteria were identified during initial telephone contact and were confirmed in the first session. The subjects voluntarily participated in the study and read and signed the free informed consent form. The study was conducted in accordance with ethical guidelines for research involving humans and was approved by the Ethics Committee of Universidade Federal de São Paulo (Protocol No. 103.217/2012).

Study design

The volunteers came to the training site on three occasions scheduled on different days according to their available time, but respecting a minimum interval of 72 hours and a maximum interval of 10 days between sessions. The interval between sessions was designed to minimize the effects of late muscle pain, which was a condition not to undergo training. All training sessions were held in the morning, starting between 8 and 9 am, to avoid variations in circadian rhythm. The subjects were asked to have their usual breakfast at least 2 hours before the intervention, which should be the same on the three days of the interventions.

The training site was an air-conditioned room equipped with free weights (dumbbells and ankle weights) and mats. The evaluations, supervision and application of manual resistance during training were always performed by the same researcher.

In the first session, the volunteers read and signed the free informed consent form and were submitted to the determination of BMI. The subjects were then familiarized with the assessment and training procedures, as well as with the RPE scale. For familiarization, the subjects performed two sets of each proposed exercise, one using manual resistance and the other using free weights. In the second session, the subjects underwent MRT and in the third session, FWRT.

Training protocols

The RT sessions consisted of seven exercises in the following order: front raise, knee flexion, fly, hip flexion, pullover, crunch, and stiff leg deadlift. Each exercise consisted of three sets of 10 repetitions, with a 1-minute interval between sets. The volunteers were asked to maintain the speed of execution close to 1 second per phase (concentric and eccentric). Before the exercises, the volunteers warmed up by performing one set of 10 repetitions of each exercise without additional load (only the movement) in a circuit. The total duration of the training session was approximately 35 minutes.

The intensity was controlled by RPE using zone 5 to 7 of the original version of the OMNI-RES scale[12]. This scale was chosen because it is specific for resistance training. The RPE scale was visible to the volunteer throughout training and the subject reported PF at the end of each set. The first set of each exercise was used for load adjustment, if necessary. Thus, if the RPE identified after the first set was outside the target zone, the load of the following sets was adjusted.

The body position adopted for the exercises (except for the stiff leg deadlift) was lying (dorsal or ventral decubitus) in order to facilitate the application of manual resistance (mechanical advantage). The body position and control of the remaining variables were identical for MRT and FWRT, with the two interventions only differing in terms of resistance (Figure 1). The techniques used for the exercise and application of manual resistance were based on Teixeira[13]. In MRT, manual resistance was applied directly to the segment mobilized during exercise, always in the direction opposite to the movement executed. A physical education professional experienced in the method was responsible for the application of manual resistance. Dumbbells and ankle weights were used for FWRT.

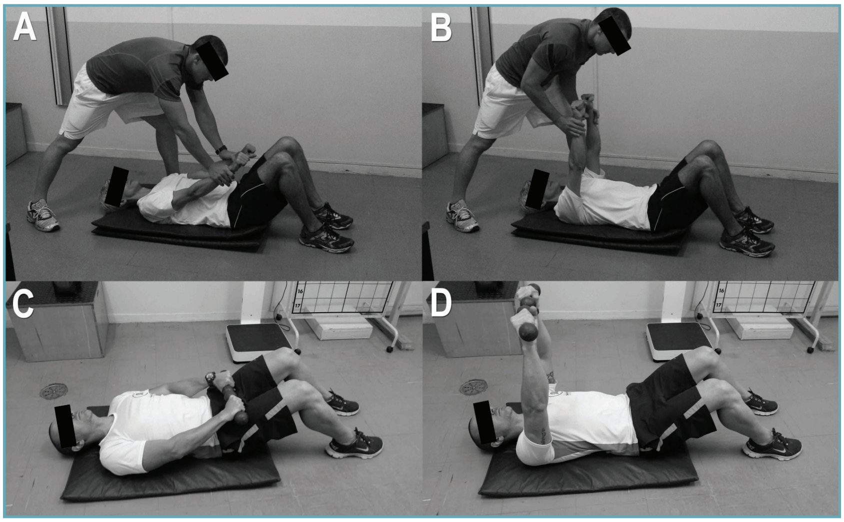

Figure 1. A: Exercise of front elevation (MRT) – initial position; B: exercise of front elevation (MRT) – final position; C: exercise of front elevation (FWRT) – initial position; D: exercise of front elevation (FWRT) – final position.

Data collection

First, the BMI was evaluated to determine the profile of the sample. Body weight was measured with an anthropometric scale (Toledo, model 2096PP/2) to the nearest 50 g. Height was measured with a professional stadiometer (Sanny, millimeter precision). The BMI was calculated as body weight/height^2.

Capillary lactate and PF were analyzed before and immediately after the training sessions. Lactate was measured with a portable lactate analyzer (Cobas, model Accutrend Plus) using specific strips and disposable lancets as described previously[14]. Perceived fatigue was evaluated using the Brunel Mood Scale (BRUMS)[15], validated for Brazil[16]. The questionnaire consists of 24 items rated on a Likert-type scale to identify levels of mood perceived by the subject at the time of application of the instrument. The scores range from 0 to 4 (0: not at all; 1: a little; 2: moderately; 3: quite a bit; 4: extremely) and are identified by answering the question "How do you feel now?". Although validated to evaluate mood levels, the instrument is divided into six factors, including PF. In this scale, the items related to PF are numbers 4, 8, 10, and 21.

Data analysis

For descriptive analysis, the results are expressed as the mean and standard deviation. For inferential analysis, the variables were compared between interventions and assessments using analysis of variance for repeated measures and Bonferroni multiple comparisons. A level of significance of 5% ($P \leq 0.05$)

was adopted. The effect size was calculated to evaluate the magnitude of differences between pre-test and post-test evaluations. The cut-off value proposed by Cohen[17] was used to interpret the magnitude of effect size: ≥ 0.8 indicates a large effect size, 0.8 to 0.2 a medium effect size, and < 0.2 a small effect size. Pearson's linear correlation coefficient was calculated to determine the association between lactate and PF, considering the *r* values proposed by Cohen[17].

RESULTS

In the pre-test evaluation, lactate concentrations were higher in FWRT. Post-test lactate concentrations were higher than pre-test values in both interventions. The increase was greater for MRT. The effect size magnitude was large in both interventions. For PF, post-test values were higher than pre-test values, without a difference between interventions. However, analysis of effect size revealed a higher magnitude for MRT (Table 1).

Table 1. Lactate concentration and perceived fatigue according to intervention and evaluation.

Variable	Intervention	Pre-test	Post-test	Effect size
Lactate (mmol/L)	MRT	1.76 ± 0.94	8.93 ± 2.18&#	7.63
	FWRT	2.26 ± 0.79*	5.39 ± 1.57&	3.96
PF	MRT	1.86 ± 1.46	4.43 ± 3.20&	1.76
	FWRT	2.57 ± 2.06	3.93 ± 2.56&	0.66

PF: perceived fatigue; MRT: manual resistance training; FWRT: free weight resistance training. Values are the mean ± standard deviation. *: P ≤ 0.05 vs MRT; &: P ≤ 0.05 vs pre-test; #: P ≤ 0.05 vs FWRT.

A moderate correlation was observed between lactate and PF, except for the pre-test condition in MRT (Table 2; Figure 2).

Table 2. Pearson's correlation coefficient between lactate and perceived fatigue.

Intervention	Coefficient	
	Pre-test	Post-test
MRT	0.17	0.45
FWRT	0.34	0.50

MRT: manual resistance training; FWRT: free weight resistance training.

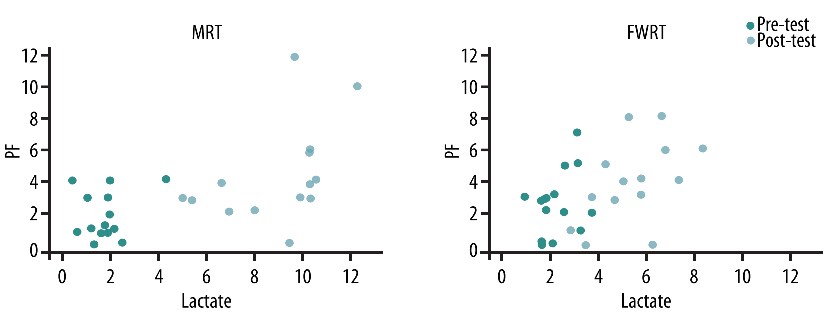

Figure 2. Pearson's correlation coefficient between lactate and perceived fatigue (PF). MRT: manual resistance training; FWRT: free weight resistance training.

DISCUSSION

This study compared the lactate and PF responses between MRT and FWRT with intensity controlled by RPE. Since RPE is a validated instrument[12] for internal load control during physical exercise, we hypothesized that adoption of the same RPE zone would lead to similar alterations in the variables analyzed in the two interventions.

There was a significant increase in post-test lactate concentrations compared to pre-test levels. This increase is expected since lactate is a subproduct of the second energy-producing metabolic pathway, a pathway preferably used in RT which consists of moderate repetitions with short intervals between sets[18], as applied in this study. The present results agree with previous studies showing an acute increase in lactate after RT sessions using different types of resistance: free weights[19], self-resistance[20], and asymmetrical pulleys and elastic resistance[21]. To our knowledge, this is the first study to analyze the acute effects of MRT on lactate levels.

Compared to FWRT, MRT induced significant increases in lactate, even when a RPE zone of 5 to 7 was adopted in both interventions. Rafo et al.[22] showed that an increase in lactate is associated with an increase in RPE during RT, i.e., higher lactate levels correspond to higher RPE values. However, this fact was not observed in the present study. Higher lactate levels are probably related to the phenomenon of accommodating resistance[7,23], which does not permit short rest in the midst of repetitions as occurs in FWRT. According to Teixeira[13], in FWRT muscle tension is proportional to resistance arm length (RAL) of the lever system, since the effect of external resistance depends on the gravitational force. Hence, muscle tension is higher at a joint angle at which RAL is greater. Muscle tension decreases with decreasing RAL, providing short periods of rest in the midst of an exercise series. One example is elbow flexion exercise with free weights (curl), in which the muscle tension is minimal (or zero) at the initial and final angles of movement. In contrast, in MRT resistance is always applied in the direction opposite to the movement, maintaining RAL and possibly muscle tension constant, irrespective of the gravitational force. This difference is more evident in single joint exercises which are characterized by angular movement, a feature of the exercises used in this study. According to Dorgo et al.[7], manual resistance varies in magnitude and direction across the range of motion in an attempt to adapt to the force produced by the subject at different angles and, thus, to make maximum use of tension at each angle. Also according to these authors, several studies speculate that exercises stimulating maximum muscle tension at each angle of the range of motion (accommodating resistance) promote greater neuromuscular adaptations than constant resistance exercises.

In conventional RT, devices using a system of cables and asymmetrical pulleys (different radii) provide accommodating resistance across the range of motion, similar to MRT[11]. One may therefore suppose that the acute lactate responses in MRT resemble those provided by devices using asymmetrical pulleys, with both types of exercise being superior to FWRT. However, studies are needed to confirm this hypothesis.

A significant increase in PF was observed after both interventions. Although the increase in lactate was higher after MRT, PF did not differ significantly between interventions. However, the effect size magnitude was greater for MRT compared to FWRT (large *vs* medium). This effect size greater magnitude might be related to the facts that 1) lactate is a physiological marker of exercise intensity[24], and 2) increased exercise intensity is a factor that influences the sensation of fatigue[25]. However, in the present study, the correlation between PF and lactate was moderate in three of the four situations analyzed (pre-test MRT, pre-test FWRT, post-test FWRT). It should be noted that PF was evaluated indirectly because of the lack of direct instruments, even subjective, for the assessment of PF. This result therefore does not support the use of this instrument to estimate lactate increases in RT, particularly MRT.

Although RPE is a validated instrument[12] and is recommended in the literature for internal load control during RT[24], different types of external resistance can elicit different responses in physiological and perceptual markers of intensity. Caution is therefore needed when RPE is applied to different types of RT.

The results obtained suggest that the adoption of the same intensity zone in RPE leads to higher physiological and perceptual stress in MRT compared to FWRT. It is therefore necessary to elaborate and validate other subjective methods for load control in RT and/or to validate an RPE tool for MRT, as well as for each different type of RT.

The main limitation of this study is the lack of randomization of the interventions. However, the previous sessions of familiarization with the procedures and interventions were intended to minimize possible interferences of the learning effect with the results. Furthermore, since two different types of resistance that require different levels of movement control (MRT: movement control assisted by the professional; FWRT: movement exclusively controlled by the subject) were applied, we believe that the order of execution of the sessions would not influence the results.

CONCLUSION

The use of the same intensity zone in RPE resulted in different acute lactate responses in MRT and FWRT. Although not significantly different, PF responses exhibited a greater effect size for MRT. Thus, the use of RPE for intensity control in different types of RT should be viewed with caution. The correlation between lactate and PF was moderate, a finding not supporting the use of PF to estimate lactate increases in RT, particularly MRT. Further studies are needed to validate the use of RPE or other instruments for the control of intensity and measurement of fatigue in different types of RT (e.g., MRT).

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